APPENDIX 32

FIRE HAZARD ANALYSIS 1006 (STAR)

September 1998

Fire Protection Assessment / Fire Hazard Analysis
Building 1006, 1006A, 1006C, STAR Experimental Complex
Brookhaven National Laboratory

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Project Concurrence: _____ 9/4/98
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Date of Survey: Various to September 4, 1998 Date of Report: September 4, 1998

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Purpose/Scope

The purpose of this assessment is to comprehensively and qualitatively assess the risk from fire within the STAR Complex at Buildings 1006, 1006A, and 1006C, and to ensure that DOE fire safety objectives are met. The assessment includes the risks from fire and related hazards (direct flame impingement, hot gases, smoke migration, fire-fighting water damage, etc.). DOE fire protection criteria are outlined in DOE Order 420.1[1], Chapter 4. The Fire Hazard Analysis required for the Safety Analysis Document for this facility is incorporated into this assessment.

Summary

The current and proposed uses of 1006, 1006A, and 1006C for the STAR physics experiment is described under "Occupancy and Associated Fire Hazards," listed below. These descriptions are based on field surveys, a review of the planned and completed installations, and discussions with STAR Project staff. This FHA describes the achievement of a reasonable and equivalent level of fire safety to meet DOE 's "Improved Risk" objectives.

Recommendations:

1) The labyrinth between the WAH and the Control Room needs to be a one-hour fire rated division to segregate the two areas of high valued equipment. Likewise, the two HVAC openings from the WAH to the Support Bldg. need to be sealed to prevent passage of smoke and heat between the high valued areas.

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[1]US Department of Energy Order No. 420.1, Facility Safety, 11/16/95

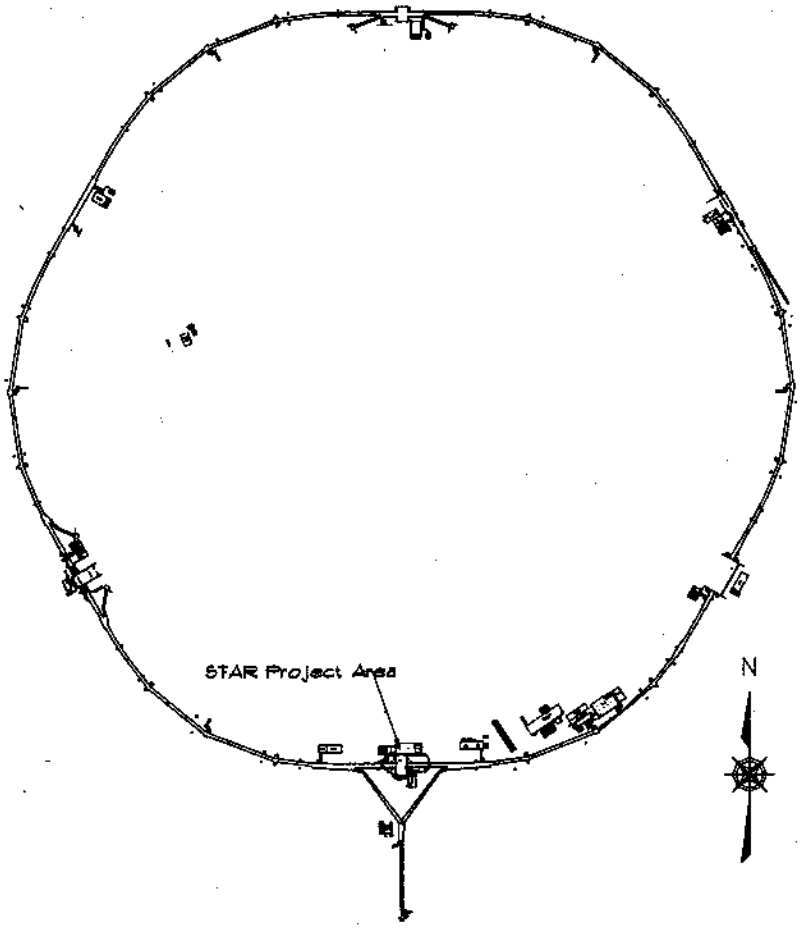
Analysis

1. Scope

This review includes the experimental facilities and support structures for the STAR Experiment at the Relativistic Heavy Ion Collider (RHIC), located at Brookhaven National Laboratory (BNL). The buildings associated with STAR are Bldg. 1006 (Assembly Hall and Intersecting Region) and Bldg. 1006A (Control Room, Technical Support Building).

1.1 Construction

The STAR Complex is located in the northern region of Brookhaven National Laboratory (BNL). BNL is a 5,000 acre site owned by the Department of Energy and operated by Brookhaven Science Associates. BNL is located in Upton, New York.



KEY PLAN
NOT TO SCALE

1.1.2 Building 1006

Building 1006 is a one story, 15,390 sq. ft. building. The building is divided into two halves. The south portion of the building is the Wide Angle Hall (WAH) built in 1981 with an approximate square footage of 5,600 sq. ft. The WAH is 40 ft. high, with reinforced concrete roof, walls and floor. To the east and west, two 900 sq. ft. openings are provided from the RHIC Tunnel. A 30 ft high shield wall fills the opening in the heavy concrete shield wall that separates the WAH from the Assembly Hall (AH) to the north. The facility is windowless and covered by several feet of earth for radiation shielding.

The AH is 60 ft. by 130 ft., built in 1997. The roof is a Class I insulated steel deck roof by Factory Mutual standards. Walls are fiberglass insulated metal panels. The floor is reenforced concrete. Within the AH a 60 ft. by 30 ft. mezzanine is located on the east side. The mezzanine is concrete poured over a metal deck and supported by a steel frame. The wall partitions are non-combustible. An insulated metal door and roll-up door is present. The partition is not fire rated. First floor rooms, under the mezzanine, have 8 inch concrete block walls.

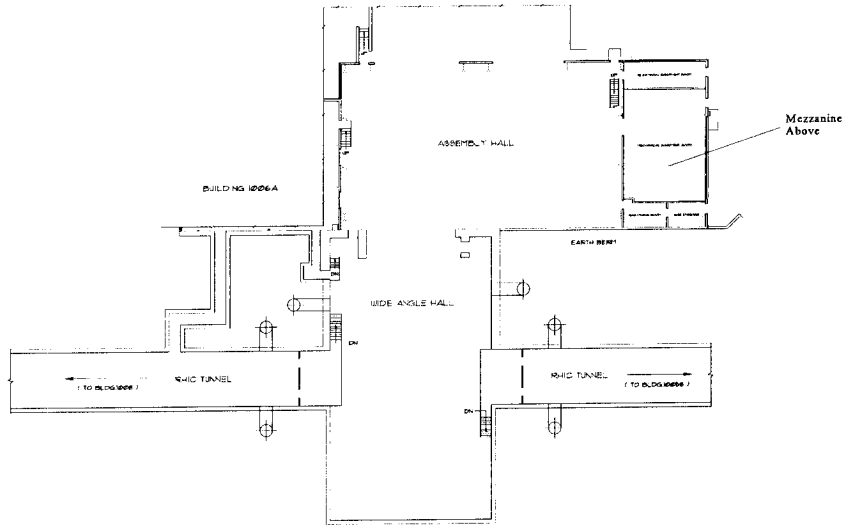


Figure 2 Plan view of Bldg. 1006

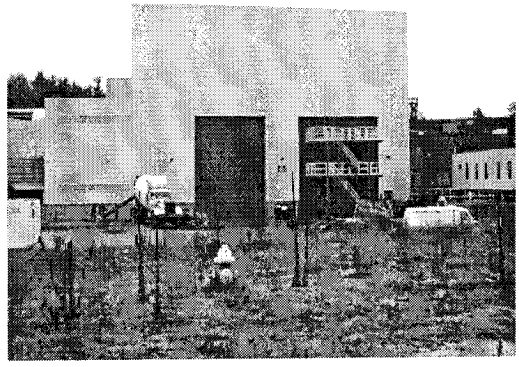
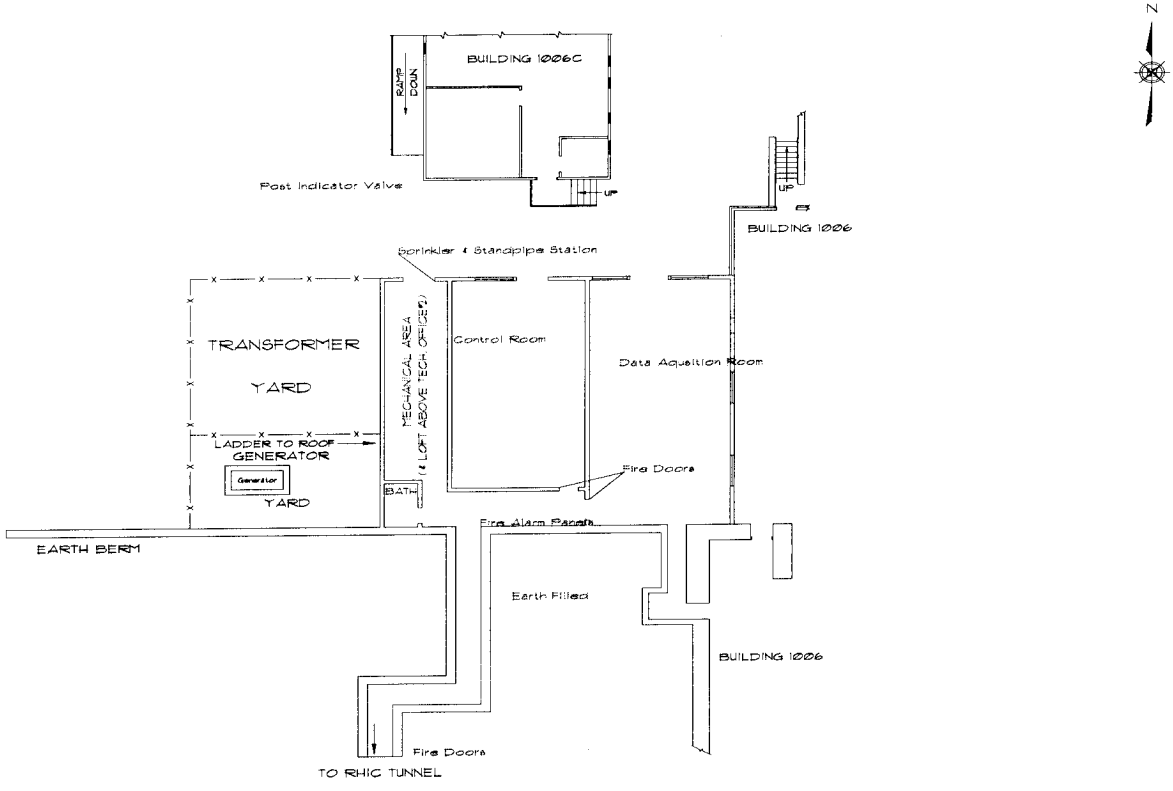


Figure 3 Looking south toward north face of Bldg 1006. On the right is the north mechanical platform of STAR, standing outside the West roll up door.

1.1.3 Building 1006A

Built in 1981 with the WAH, the Support Building is a one story fiberglass insulated metal panel building of 2,800 sq. ft. The steel deck roof is rated as Class I by Factory Mutual Standards. Interior walls are 8 inch concrete block. The floor is reinforced concrete. A labyrinth connects Bldg 1006A to the RHIC Tunnel.



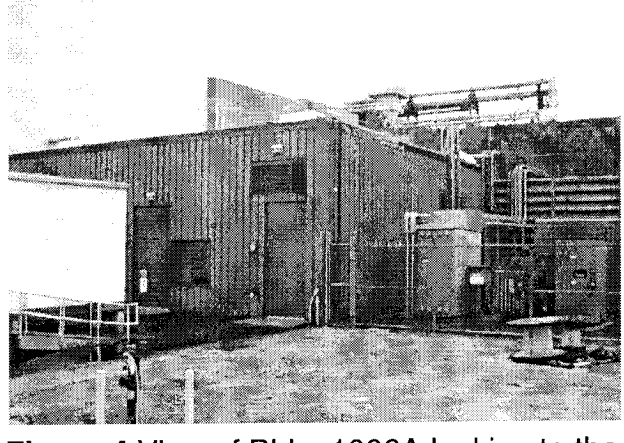


Figure 4 View of Bldg. 1006A looking to the south

1.2 Fire Barrier Integrity

The majority of the dollar value for the facility is in the STAR Detector (>$60 million design and construction costs; replacement cost of $30 million). The Detector primary location is the WAH. The Detector is transferred to the AH for servicing (a few times per year). The RHIC Tunnel opens to the WAH to allow the Beam Transport System (a string of magnets) to enter the WAH. Normally, a fire rated barrier would be installed to segregate the high value accelerator from the WAH. A fire rated barrier was not installed. The following is a list of mitigating features:

1) Low combustibility of RHIC Tunnel and contents (See RHIC SAD).
2) Spot smoke detection in tunnel, on alternating zones for reliability and with separate redundant rate of rise/fixed temperature heat detection units at each detector location.
3) Automatic smoke removal system (in the tunnel and WAH).
4) Highly sensitive smoke detection in the WAH.
5) Highly sensitive smoke detection in the Detector.
6) Low combustible contents and construction of the detector.
7) Ceiling mounted wet pipe sprinkler system in the WAH.
8) Vapor barrier for the oxygen deficiency hazard posed by Helium will also act as a smoke barrier between tunnel and WAH on both sides (Herculite fabric on metal frame).

This arrangement deviates from DOE's requirement to isolate high value equipment with fire rated construction. By way of this document, an exemption request is being processed

The first floor south, under the mezzanine, contains the gas mixing equipment. Original design has changed and while the room was constructed with a 2 hour fire rating, the bulk gas systems are now outside (see gas system section). The room no longer requires a fire rating, nor the explosion protection for electrical equipment. Solid piping passes through this area into the gas mixing equipment. There are no relief valves nor are there frequently made or broken connections. Therefore this area is not exposed to combustible gases. Fire dampers in the communicating wall to the AH have been removed from the west wall and the room is no longer fire rated.

1.3 Windstorm Damage Potential

Bldg. 1006 and 1006A steel deck roofs are in good repair and are expected to withstand local windstorms.

Portions of the STAR Detector have fragile gas chambers. Rapid fluctuations in atmospheric pressure can cause damage. While hurricanes have the highest wind speeds, the most severe pressure drop in 40 years at BNL has occurred during the "Northeaster". Pressure dropped ½ inch of water column within ½ hour. This was used as the design basis for chamber design. See RHIC Experimental Safety Review Committee for details.

2.0 Occupancy and Associate Fire Hazards

2.1 STAR Detector

The STAR Detector main structures consists of the Main Magnet, North Platform and South Platform. The Main Magnet is a 5.6 meters by 6.2 meters long solenoid magnet made from aluminum coils and 1,200 tons of steel. Various subsystems are used to detect interaction events from the intersecting heavy ion beams which cross at the center of STAR. A beryllium beam pipe is used to transport the beam through the magnet. The Detector has an array of subsystems. In the center is the Silicon Vertex Tracking (SVT) Detector. It is an assembly of low mass circuit boards and wafers on a beryllium frame. The combustible metal is of sufficient thickness not to pose an easily ignited combustible material, even if the RHIC beam impinges on it (maximum calculated temperature rise of 1 degree C with impingement). During the design of STAR's various detector subsystems, materials were selected to be low combustibility (FR4 printed circuit boards, fire rated cables).

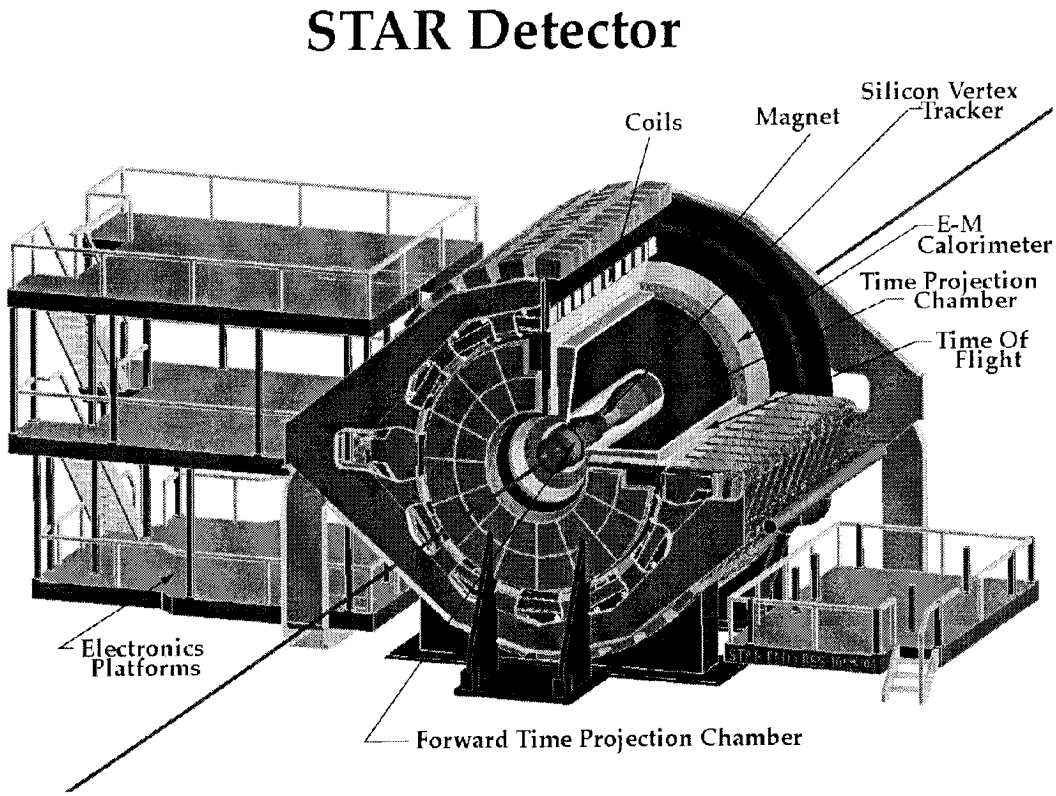


Figure 6 A sectional view of the Detector with the two top most north platform removed (north is to the right).

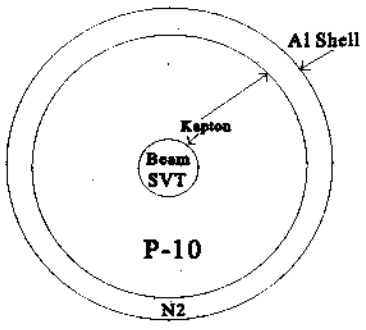
The ignition sources were limited by Overcurrent protection to the board level. During RHIC Experimental Safety Committee Reviews a 80 watts maximum over current load was established. Most designers of sub systems choose polyfuses for over current protection. Polyfuses are semi conductor devices that shutdown at twice their rated operating currents. Polyfuses remain "off" until all power is removed from them, thereby allowing remote resetting while latching under fault conditions. The intent was to limit maximum power dissipation, provide a highly sensitive detection system on the magnet to turn off power, and to have materials that self extinguish when small initiating power is terminated.

2.1.1 STAR TPC

One of the subsystems at STAR, the Time Projection Chamber (TPC), has an inventory of 50,000 cubic liters P-10. P-10 is a blend of 10% methane in 90% argon. Therefore the TPC has a potential inventory of 5 m^3 of methane, although it is diluted with an inert gas. While this blended gas is classified as a non-flammable gas by the Department of Transportation, it does support combustion (mainly by methane diffusion from the blend [2]). Therefore, STAR has approached this situation by treating the P-10 as a flammable gas to ensure sensitive equipment is not severely damaged.

The TPC is cylindrical in shape. The 1 meter diameter middle opening is for the beam pipe and the SVT. The next concentric opening is the Inner Field Cage, which is a cylinder of two layer of aluminum coated Kapton on a honey comb Nomex structure. The next cylindrical volume is a blanket of P-10 gas. The Outer Field Cage is the next cylindrical boundary, which is Kapton coated with copper. A Nitrogen blanket is in the next cylindrical volume followed by the aluminum shell. The shell is aluminum honeycomb on both sides of a 2 mm aluminum skin. 30 kV potential is applied across the cages. The inner system systems operate at 5 milibars of pressure, while the external shell can withstand 5 psi.

The two faces of the TPC are two part solid aluminum frame work. A honeycomb of oblong openings in the frame allow the passage of electrical signals. FR4 boards were to seal the openings (under 10% are G-10).



Process controls will measure moisture and oxygen content. These will be interlocked to shutoff power and start a purge unacceptable conditions occur. The TPC will purge the P-10 with nitrogen at the rate of 450 liters per minute, taking approximately an hour and one half to displace one volume. Since any dilution by an inert gas of P-10 moves it out of it's explosive range, this is acceptable.

Figure 7 Simple Cross Section of TPC

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[2] Department of the Interior, US Bureau of Mines, Bulletin 627, Characteristic of Flammable Gases and Vapors, 1965

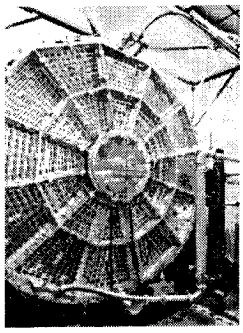


Figure 8 View of TPC aluminum end frame.

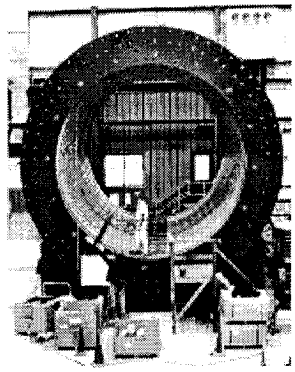


Figure 9 A view of the Magnet Coils during construction, representing almost 1,200 tons of steel. TPC slides inside of the coil.

STAR will blend their own mixture of P-10. Strict controls and redundant systems are used to monitor the proportions of Argon to Methane for operational and safety reasons. Gas is monitored as it is mixed and recirculated within the TPC. The bulk supply of gas is stored to the east of Bldg. 1006 in an outdoor location. It is delivered into the building through metal piping, protected from mechanical damage. Mixing occurs through controllers in the Gas Mixing Room.

For the purpose of classifying this facility for Fire Code applications, the occupancy is an ordinary hazard industrial facility.

The North Platform of STAR contains mainly mechanical services, monitoring systems for the magnet, water pumps, and some water cooled electrical buss. There is no unusual fire hazards associated with this use.

The first two levels of the South Platform has the majority of electronics and is the most vital. The highest value is located on the first level, row "A". These are the trigger electronics with a value of $250k per each of two double width rack enclosures. The electronics and power supplies do not pose an unusual fire hazard. Metal cabinets house the majority of the equipment. Metal dividers aid in the segregation of equipment. The electronics were designed using less combustible materials for printed circuit boards (FR4) and cabling. The protection of the electronics is under electronic data processing section of this report. Several power conduits were constructed of PVC plastic due to the need for electrical isolation and experimental signal quality. These run under the magnet and do not expose the Platforms.

2.2 Assembly Hall

The AH has the same hazards as the WAH. P-10 will not be present in the Detector when it is moved form the WAH to the AH. P-10 may be present in the AH during servicing.

Two small hydraulic systems are used for moving the Detector. Reservoir on both systems are under 50 gallons and develop several thousand psi. Factory Mutual less flammable liquids are used. The hydraulic systems are connected to the Detector only during movement. The systems are manual and operations are constantly supervised as per an Operating Procedure.

Located on the mezzanine of the AH are main magnet power supplies, water systems for the magnet, MCWS, Power Supply/Buss, and the cooling tower. Water systems include pumps, filters, and resin beds. This equipment is considered common industrial hazards. The water cooled power supplies are not oil insulated. This area is an ordinary industrial occupancy.

The first floor, north area, under the mezzanine in the AH houses dry type power transformers for normal building support services. This is fully sprinklered and not fire rated. The first floor also contains electrical control centers and water systems (pumps, chillers, water treatment equipment).

2.3 Bldg. 1006A

Bldg. 1006A DAQ Room will house data acquisition equipment, control and monitoring systems. Data storage will only consist of a buffer set of information in case the mass storage link is unavailable. Mass storage will be provided at the Brookhaven Computer Facility's RHIC Computer Facility subsystem which is located several miles away (subject of separate reviews). In the Control Room, process and safety control systems will reside. These areas are low hazard occupancies, from a fire hazard standpoint.

3.1 Critical Process Equipment

The STAR Detector is divided into several sub-systems, some of which are not needed for the entire experiment to operate. However, without the full compliment of systems, the quality of physics will suffer. The following is a matrix of subsystems, total construction costs (including engineering, design), and a replacement value for as-is systems.

System	Total Cost	Estimated Replacement Cost
Conventional Systems	$1.5 million	$1.0 million
Magnet	$11.4 million	$4 million
Time Projection Chamber	$11 million	$5 million
Forward TPC	$2.4 million	$1.5 million
Electro Magnetic Cal	$11 million	$7 million
Front End Electronics	$4 million	$1.5 million
Silicon Vertex Tracker	$7 million	$4 million
Computing (DAQ, Processing)	$5 million	$3 million

The Support Systems (such as Magnets, cooling water, electrical power) are required for STAR operations. The majority of components in these systems are common and easily deliverable. Custom parts in other sub systems do have limited spares. The major exceptions are the large structural elements, such as the Main Magnet, and TPC. It is impractical to have spares for these massive devices. Concurrently, it is unlikely that an event will inflict significant damage to these devices.

3.2 Special Occupancies

Special occupancies include electronic data processing and vital/important records. The special occupancies of STAR and Bldg. 1006 are expanded upon in Sections 3.2.1 and 3.2.2, below.

3.2.1 Electronic Data Processing
The data acquisition equipment (DAQ) associated with the operation of STAR is located in a DAQ Room in Bldg. 1006A. Dollar values for control equipment exceed $1 million, but are under $10 million. The facility is a non-combustible construction, segregated from other occupancies by one hour fire walls (except for the division between the AH and the DAQ Room, see below), provided with smoke detection, and protected by a wet pipe sprinkler system. The labrinyth to the WAH from the DAQ Room is not fire rated. This labyrinth needs to be sealed (see Recommendation #1).

The separating wall between the DAQ Room and the AH is also not fire rated. The insulated metal wall has sprinkler protection on both sides. In addition, HSSD early warning smoke detection is provided on the AH side. The occupancies are similar and do not warrant an increased level of segregation. The overall arrangement poses an acceptable risk when recommendation #1 is completed.

The Control Room is adjacent to the DAQ Room. The area contains workstations and terminals. Dollar value is low. The room is segregated from the DAQ and adjacent mechanical spaces by 8 inch concrete block walls. The non-fire rated separations are adequate for the risk.

3.2.2 Vital and Important Records Storage

Vital records are those records which are essential to the mission of an important program and which, if lost, could not be reproduced or obtained elsewhere. Important records are those records possessing a high value to the mission of an important program but which, if lost, could be reproduced or reconstructed with difficulty or extra expense.

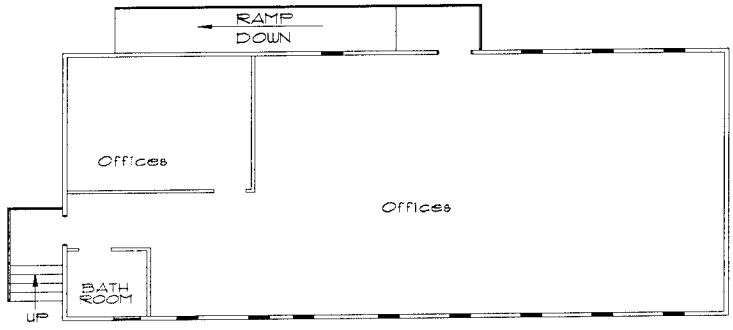
Based on the above definition, the data collected from the experiment is vital. This information is collected by the facility and transported to the RHIC Computing Facility in Bldg. 515, Brookhaven Computing Facility (separate facility several miles away, connected by computer network). Except for a minimally sized buffer arrangement, on-site storage of data in not done. The petabytes of data are the subject of another analysis for the RHIC Computing Facility, located several miles away.

3.3 Unique Fire Hazards

Unique fire hazards include; modular buildings, trailers, cooling towers, flammable liquid and gas storage, cable trays, housekeeping in vital areas, and highly combustible building materials. The unique fire hazards at the STAR Complex are expanded upon in sections 3.3.1 through 3.3.7, below.

3.3.1 Modular Buildings

Bldg. 1006C was built in 1992. The facility was formerly Bldg. 831. It was relocated in 1996 to the south side of Bldg. 1006, and renamed Bldg. 1006C. The facility is constructed from three prefabricated modular units, with a total floor are of 1,700 sq. ft. The assembly is one story with a framed roof. Fiberglass insulation, metal studs, and metal framing were used throughout. The floor deck is plywood, covered carpet (Class I rating by Radiant Panel Test).



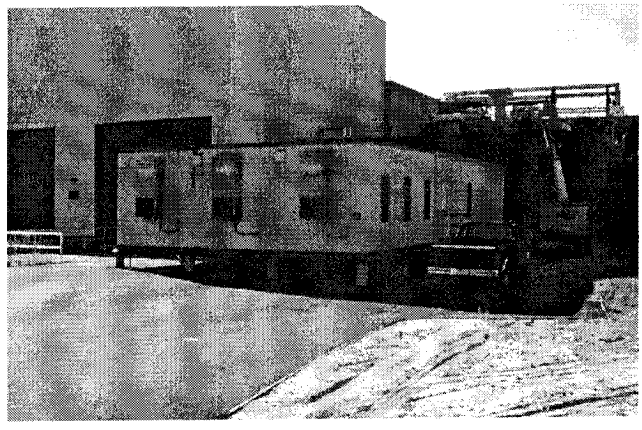


Figure 11 View of Bldg. 1006C looking toward the south.

3.3.2 Trailers

Currently there are no funded plans for additional buildings around STAR. If facilities are provided, they will comply with DOE Orders on separations, construction, and protection.

3.3.3 Cooling Towers

The experiment has a water based heat removal system. One cooling tower is located to the east of Bldg. 1006. The unit is metal, prefabricated, and serves the STAR Magnet, MCWS, and Power Supply/Buss cooling systems. There is no fire exposure concern.

3.3.4 Flammable Liquid/Gas Use and Storage

The TPC at STAR uses P-10 as a detector gas. It is a blend of 10% methane and 90% argon. It is considered non-flammable by the Department of Transportation. However, studies by the US Bureau of Mines show that the gas can ignite and burn (mainly from defusion of methane). The studies also indicate that any minimal amounts of ventilation will dilute the gas below the Lower Explosive limits for Methane. The STAR project is treating the gas as flammable gases. The inventory is large, 50,000 liters. A study was performed to analyze the potential for damage (Design Basis Accident, see STAR SAD). The events postulated show that the damage does not involve areas beyond the WAH and gas mixing room.

The RHIC Experimental Review Committee has examined the design and installed configurations of the Detector and its sub systems.

Release of gases into the WAH have been addressed as follows:

1) Limits to on-line supplies for flammable gas systems,
2) Solid metal piping from the supply to the Detector's distribution systems,
3) Requirements for leak checking of piping systems following modifications & repairs,
4) Detector chambers are designed to ensure integrity (burst safety factor)
5) Pressure tests that assure chamber construction meet design boundary limits,
5) Designs that "fail-safe" with loss of power (i.e., purge of flammables with inert gases),
6) Combustible gas detection in the regions where gas could be released and could collect,
7) Highly sensitive smoke detection to promptly indicate off normal conditions,
8) Interlocks to shut off all power to the Detector in the event of certain fire alarm conditions (and starts purge/vent),
9) Over current protection of power distribution system on printed circuit boards within the STAR Detector to limit maximum power dissipation potential under 80 watts on one board,
10) Normal ventilation in the WAH to dissipate combustible gases ("normal leakage"),
11) High rate purge, activated with interlocks, in the WAH to dilute and remove released gases,
12) Monitoring of oxygen content of detector gas at gas mixing and in the recirculation stream.

Gas releases into the AH have similar protective measures, except the AH has a higher natural air exchange rate provided by the type of construction. The AH's steel deck construction and numerous external openings provide better ventilation of methane than the WAH's sealed concrete structure. The AH does not have an emergency exhaust system. The RHIC Experimental Safety Review Committee reviews and establishes the required controls of the P-10 use in the AH. This is expected to be an infrequent event, occurring during servicing.

3.3.5 Cable Trays

High voltage, low voltage, control, and signaling cables are segregated in accordance with NEC requirements throughout the STAR Complex. The cabling is located in conduits, raceways and cable trays. In most instances, the cables provided in the cable trays meet the RHIC flammability test criteria (IEEE 383, VW-1, NEC rated wire for cable trays). Automatic sprinkler protection is provided in the Bldg. 1006, WAH, AH, DAQ Room, and Control Room.

3.3.6 Housekeeping in Vital Areas

For this high value facility, good housekeeping and control of combustibles will be essential. Internal self inspection will be routine and an aid in evaluating the effectiveness of the program.

3.3.7 Highly Combustible Building Materials

No significant amounts of exposed polystyrene insulation or other highly combustible building materials are used in the construction or operations at the STAR Complex.

The North and South Platforms are constructed of metal frames. Resin particle board, with a Resin Decking finished, has been installed on the platforms to provide a walking/working surface. This decking was chosen for its ridigity and comparative low weight. Resin Decking does not have a significant flame spread concern due to the open nature of the platforms. To provide structural ridigity, aluminum sheet metal was attached directly to the underside of the decking. The metal will prevent ignition in the event of a cable tray fire (trays are run below the decking; cable are low flammability and easily accessed).

To provide electrical isolation between the North and South Platforms, PVC electrical conduits were installed. These are short run, beneath the heavy steel of the magnet and do not expose the detector to damage.

4.1 Fire Protection/Suppression Features

4.1 Infrastructure Support

4.1.1 Site Water System
BNL has a combination domestic and fire protection water supply system. The system is supplied by several deep wells and is stabilized by two elevated water storage tanks (one 1 million gallon and 350,000 gallon capacity). The wells have electric primary drivers and a limited number have backup internal combustion drivers. The system can sustain three days of domestic supply and a maximum fire demand (4000 g.p.m. for 4 hours) for BNL with two of the system's largest pumps out and one storage tank unavailable. The piping distribution network is well gridded. Water supplies around the RHIC Ring Road are fed from two well separated connections to the BNL system. Ample valves provide isolation in case of a main break. Static water pressure to the STAR complex is typically 70 psi. Water supplies to Bldg. 1006 and 1006A are capable of supplying 1,700 g.p.m. with 60 psi residual pressure.

Fire hydrants are provided within 300 ft. of each facility. Frost proof hydrants are needed since the frost line extends to 4 feet below the surface in the winter. BNL and the local Suffolk County Fire Departments use National Standard Thread couplings.

BNL's Plant Engineering Division maintains the water supply system. BNL's Fire/Rescue Group conducts valve inspections on the distribution system to ensure reliability of firefighting water supplies.

4.2.1 BNL Fire/Rescue Group
The BNL Fire/Rescue Group is a full time, paid department. Minimum staffing is five firefighters and one officer per shift (Fire/Rescue Staff & Organization). The firefighters are trained to meet Firefighter Level III by International Fire Service Training Association standard , National Fire Protection Association (NFPA) Fire Fighter Level II standard, and (NFPA) Hazardous Material Technician Level and they are Suffolk County Certified Confined Space Rescuers.

The BNL Fire/Rescue Group also provides emergency medical services to an on-site population of 3200 people. A minimum of two members per shift hold New York State "Emergency Medical Technician - D" certifications ("D" is for defibrillation). Normally all five firefighters have EMT status. The Group operates a New York State Certified Basic Life Support Ambulance (a 1988 Wheeled Coach Type I on a Type III Chassis). Medivac services are available to BNL via the Suffolk County Police Department (a training session).

Additionally the Group has two 1500 g.p.m. "Class A" Pumpers, one Rescue Vehicle for initial hazardous material incident response and heavy rescue operation, one Command Post Vehicle, and one 5 ton military chassis converted to a Long Island Style Brush Truck.

The single Fire Station is on the west side of the BNL's property. Response time to the most remote section of the BNL is less than eight minutes (if not out of quarters on another emergency response call). RHIC represent one of the most remote areas. Future plans may reduce this response time to less than 4 minutes with the addition of an access road from Upton Road to Ring Road.

BNL participates in the Suffolk County Mutual Aid Agreement. This allows the resources from over 130 departments to assist BNL. BNL is also a member of the Town of Brookhaven Foam Bank and Town of Brookhaven Hazardous Material Mutual Aid Agreement.

4.1.3 Site Fire Alarm System

Brookhaven National Laboratory provides central fire alarm station coverage by an Underwriter Laboratory listed multiplexed Site Fire Alarm System. The system is a Wormald System 1000, installed in 1987 (Wormald is now know as Grinnel Fire System). The system complies with the requirements of NFPA 72 for a Style 7D System.

The system uses the existing site telephone cable plant. RS232 signals are sent via full duplex line drivers. Each fire alarm panel has two channels connected to the Central Station. The panels are divided into 7 communication "loops." The system can monitor more than 20,000 points. It is currently monitoring 3,800. Response time from alarm at the panel to alarm indication at the Central Station is less than 10 seconds, which is well within the 90 seconds allowed by NFPA 72.

The main console is at the Firehouse, Bldg. 599. This station monitors all fire alarm signals, trouble and communication status alarms. A satellite station is provided at Safeguards and Security, Bldg. 50, and receives only the fire alarm signals. If the Firehouse does not acknowledge an alarm within 90 seconds, the satellite station at Bldg. 50 will receive an audible indication to handle the alarm. A second satellite station is provided at AGS Main Control Room, Bldg. 911, and receives only the fire alarm signals from the RHIC/AGS accelerator buildings. A team of operators and Health Physics Support personnel respond during accelerator operating times.

4.1.4 Fire Extinguishers

Fire extinguishers have been installed throughout the facilities in accordance with NFPA 10. Clean agent units are installed in the WAH, AH, and Control Room. Multipurpose units are installed in the other conventional areas. Although the distribution of these units meet NFPA 10, the access to burning materials within STAR will be difficult, if not impossible, with hand held units (height of equipment, depth and density of equipment). Attempts to acquire streaming type Wheeled Clean Agent units have not been successful.

4.2 STAR WAH

4.2.1 Highly Sensitive Smoke Detection System (HSSD)

To provide early warning in both the WAH and the Assembly Hall, the High Bay area are provided with a Highly Sensitive Smoke Detection System (HSSD). The ceiling heights in excess of 50 ft. prompted the need for a detection system with greater sensitivity than the standard spot type of detectors. The air aspirating type of detection has a ceiling mounted network of pipe. The sampling ports have been designed in accordance with the manufacturer's Underwriter's Listing. The ceiling piping has been labeled with orange pressure sensitive "Fire Alarm" labels. Sampling ports have been marked with blue tape. The system has been tested to verify conformance with design response time. Twenty four hour battery backup and emergency generator power has been supplied.

The HSSD system provides three levels of alarm. All three alarms report back to the BNL on-site Fire Department via the Site Fire Alarm System. The first level alarm is a local alarm (intended for the control operators). Second level alarms also sound locally, but require an investigation by Fire/Rescue. Third level alarms require full response by Fire/Rescue. Third level alarms from the WAH also activate building audible/visual devices, STAR Detector experimental power off, emergency Detector vent/purge, and building emergency exhaust fans. The HSSD system complies with NFPA 72 and the UL listing. Building fire alarms have battery backup (24 hour capacity) and emergency generator power (24 hour capacity). This system, combined with the on-site Fire/Rescue Group, satisfies the DOE requirement for a redundant fire suppression system for loss potentials over $50 million.

4.2.2 STAR Detector Electronics Cabinets

On the STAR Detector, electronics will be housed in enclosed racks on the North and South Platforms. The most significant racks are on the two lower levels of the South Platform. Given the high value of the equipment, smoke detection has been installed at the first and second levels (third level is directly under the ceiling HSSD). On the first level, one segment of racks has been provided with Inergen due to its value. The detection and release system travels with the Detector and is tied into the building fire alarm system (except during actual movement when everything is powered off and P-10 gas is removed). Building fire alarms and the Rack Fire Alarm Panel have battery backup (24 hour capacity) and emergency generator power (24 hour capacity).

4.2.3 HSSD on the Detector

Within the STAR Detector, an HSSD System will be installed. The detection system will monitor the volumes around the interior electronics. Similar to the WAH HSSD, the units will have three levels of alarm. First level alarms will require STAR Detector operator attention. Second level alarms will involve the operator and the Fire/Rescue Group for investigation. A third level alarm will evoke electrical shutdown, flammable gas detector purge/vent sequences, and building emergency exhaust ventilation for the WAH.

This application of HSSD technology does not fit standard installation rules. Best engineering judgement has been used for detector port placement. Factors influencing placement included normal air flow, collection points for smoke, location of ignition sources (electronic printed circuit cards, power devices as opposed to signal circuits). Detector ports have been spaced at 400 sq. ft. spacings. The HSSD Control Panel is tied into the building fire alarm system and will activate building wide audible/visual devices upon third level alarm. Building fire alarms and the HSSD system have battery backup (24 hour capacity) and emergency generator power (24 hour capacity).

4.2.4 Combustible Gas Detection on the Detector

Within the STAR Detector, an air sampling system combustible gas detection system will be installed for experimental operations using flammable gases. The air sampling system consists of a network of tubes that connect to a selector valve system. The selector valves and detection assembly will be located outside of the WAH. Sample points will be located on and around the detector based on potential leak points, potential collection points, normal air flow patterns, and the detector's construction. There is no installation standard for this type of application. The "off the shelf" flame ionization system uses a selector valve system to cycle through the sampling tubes and monitor combustible gas levels. Detection cycles and lengths of sampling points will ensure response to a leak within 90 seconds. Individual channel values are displayed and programmed for alarm and output functions. There will be warning levels in the ppm range, in which operators will investigate and monitor the situation. Higher reading will force action levels at 25 % of the Lower Explosive Limit, which will entail notification of Fire/Rescue, electrical shutdowns, activation of building emergency ventilation systems, vent and purge of detector chambers. The system will be on emergency power to provide continued operations during power outages.

4.2.5 Special Consideration for Electrical Isolation of Power

The Detector requires that the power and signal circuits be isolated from general building ground. Inadvertent grounds will create an electrical noise and mask signals form the Detector. To accommodate the need for isolation, the fire alarm system required several unique arrangements. A sub panel was installed on the platform. The output for alarm and trouble signals required isolation from the building fire alarm panels. This was accomplished by using a supervised output from the subpanel to a relay at a ground isolation terminal strip in Bldg. 1006. The fire alarm panel monitored the contact closures from this relay via a supervised circuit. This maintains alarm, trouble and ground fault supervision of all parts of the sub panel alarm circuit. The general trouble condition from the subpanel is connect to the ground isolation terminal strip by a normally power relay from the general trouble relay in the subpanel. A supervisory circuit monitors the relay at the isolation terminal strip. This has a fail safe trouble condition for indication of subpanel trouble. It does not have ground fault supervision from the subpanel to the isolation terminal strip.

The power for the subpanel is supplied from the clean power provided to the platform. Since a gas alarm or fire alarm condition will remove all power from the Detector, the subpanel will loose normal AC power. The 24 hour battery back up will carry the panel during this abnormal condition.

4.3 AH and Bldg. 1006A

4.3.1 Wet Sprinkler System

To provide suppression of a disastrous level fire in the WAH and the AH, a wet sprinkler system has been installed. Installation of the sprinkler system complies with NFPA 13. The system protecting the WAH has been designed to provide a .17 g.p.m. per sq. ft. density over 3,000 sq. Ft. with 250 g.p.m. for hose streams (NFPA 13 Standard). The AH system is supplied by the same riser station as the WAH. The AH system was installed as a Pipe Schedule System. Waterflow alarms are tied into the building fire alarm. Sprinkler valve supervision report through the Site Fire Alarm System as supervisory devices.

Standpipes are provided to the WAH and AH via the wet pipe standpipe system serving the RHIC Accelerator Tunnel.

4.3.2 DAQ and Control Room

Automatic sprinkler protection has been provided in the DAQ and Control Room. Both areas have been provided with ceiling mounted smoke detection. The DAQ has a raised, computer type floor, under which spot smoke detection has been installed. The DAQ Room has an Intergen system installed, protecting the high value electronic racks. Smoke Detection is provided within the racks. These provide an alarm only signal. Release of the Intergen is by rate compensated fire detectors located within the rack. Any fire alarm signal from the rack will cause the power to be disconnected from the rack. All fire alarm signals and supervision go to the Site Fire Alarm System.

4.4 STAR Counting House

The STAR Counting House is a separate structure (Bldg. 1006C). It is provided with smoke detection and manual fire alarm stations. Local audible/visual devices are provided to alert the building occupants. Building fire alarms have battery backup (24 hour capacity) and emergency generator power (24 hour capacity).

The fire protection/suppression features of vital programs, high valued property, and essential safety class systems at the STAR Complex are expanded upon in Sections 5.1 through 5.3, below.

5.1 Fire Protection of Vital Programs

The operation associated with this facility is not considered to be a DOE "vital program." Therefore, no special fire protection precautions, beyond those that are generically described above, are required for this facility.

5.2 Fire Protection of High Value Property

The majority of the dollar value is concentrated in the WAH and the DAQ Room. During periods of maintenance, the STAR Detector is relocated to the AH. With over $30 million (replacement value) concentrated in the WAH, multiple fire systems have been installed.

The HSSD detection system on the STAR Detector, combined with the on-site Fire/Rescue Group, is considered the primary response system. This system will summon aid at the earliest practical stages (local alarms and signals to Fire/Rescue) and initiate protective actions (power off, vent/purge flammable gases, activate emergency ventilation in the WAH). Smoke detectors have been placed above the platform racks and initiate the same actions as the HSSD. Great effort was made during the design stages to keep the amount of combustibles low as reasonably achievable. To this end, printed circuit boards were FR4 (self extinguishing). Wires, cables, and materials were also specified as self extinguishing (see Section 3.3.5). The intent was to have materials that would self extinguish upon removal of power.

The most likely source of ignition on the STAR Detector is the power for electronics. To minimize the Detector loss potentials, a HSSD system was installed on the detector. The equipment is Underwriter's Laboratory Listed. Sampling ports and tubes were located to monitor electronics. Standard installation rules cannot be applied to a piece of equipment. Detection ports were placed based on air flow and ignition source location.

Response to the three level of alarms will be:
1) first level is local to The STAR Control room,
2) Second level alarms at The control room and at Fire/Rescue for an investigative response,

3) third level alarms are fire alarms, ringing building bells, sending signals to control room and Fire/Rescue, and initiating interlocks (shutoff electrical power to STAR WAH, vent/purge of detector, building emergency ventilation system).

Control and set points of the HSSD system are administered through the Site Fire Alarm System configuration control procedures.

A secondary level of protection is provided by the building's ceiling level HSSD system. It will detect a fire in the WAH/AH and start the same protective actions as the HSSD on the Detector.

A third level of protection will be provided by the Building's wet pipe sprinkler system. It is anticipated that this will only activate when a sustained fire occurs in the Detectors and all other controls have failed.

The primary and third level protective systems, described above, are installed to meet DOE's requirements for redundant fire system in high value areas.

The Data Acquisition Room has over $1 million worth of equipment. This room is protected by ceiling level smoke detectors. A wet pipe sprinkler system is also present. Due to the high value of several racks, additional fire suppression systems are provided. DAQ Room Rack Row "A" will have an Inergen system. The system will have smoke detection internal to the rack for early warning. Addressable fixed temp programmable detectors will also be mounted in each rack for clean agent release. Smoke detectors are programmed as "dual level" smokes. The first level provides a local audible alarm and notifies the Fire/Rescue Group of a low level alarm. The second level will shut down power in addition to setting off the building alarm system and notifying the Fire/Rescue Group of a second stage alarm. Rate compensated fixed temperature heat detectors release Inergen into the rack where detection has activated.

5.3 Protection of Essential Safety Class Systems

There are no essential safety class systems associated with this non-nuclear facility.

6. Fire Loss Potentials

Fire loss potentials are classified into three major categories; the maximum credible fire loss, the maximum possible fire loss, and the recovery potential. The loss potentials for the STAR Complex are expanded upon in sections 4.1 through 4.3, below.

6.1 Maximum Possible Fire Loss (MPFL)

The Maximum Possible Fire Loss (MPFL) for STAR is estimated to be $30 million (replacement costs). The event would include a fire in the Detector that burns and involves the Detector's central region. The steel for the magnet would not be damaged (insufficient heat release to damage 1,200 tons of steel). Coils would be damaged, and the two Field Cages would be lost. The fire is not likely to spread from the central region and onto the platforms. However the electronics on the platforms will experience some smoke damage.

6.2 Maximum Credible Fire Loss (MCFL)

A worst case, normal fire will result in the loss of a Detector sub system. Sustained burning of a portion of a system will result in upwards of $1 million in damage. The fragile nature of the SVT makes it the most vulnerable to complete damage, although it does not have the power nor the combustible mass. The recovery time for STAR damage would take several months. Portions of the STAR could be operated without certain subsystems. This would degrade the quality of the physics. STAR could be extracted from the WAH to allow resumption of other RHIC experiments.

6.3 Recovery

Recovery time from the MPFL would be several years.

Recovery time from the MCFL would be many months.

STAR could be extracted from the WAH, a beampipe installed, shield blocks replaced, and RHIC would be able to run. This operation would take a month or more.

7. Security Considerations Related to Fire Protection

There are no security considerations which relate to fire protection at this facility. Radiation Security barriers comply with the Life Safety Code for egress.

7.1 Exposure Fire Potential

The STAR Gas mixing operation and gas storage pads meet the National Fire Protection Association and Factory Mutual Loss Prevention Data sheets separation guidelines. They are not considered exposures of concerns to the main facility.

The electrical sub station to the north of Bldg. 1006A for experimental power and the "house" power from the sub station to the west meet the Factory Mutual Loss Prevention Data Sheet on electrical transformer yard separation. The emergency generator is separated by a two hour fire wall from the "house" transformer yard. These are not exposures of concern to Bldg. 1006.

Bldg. 1006C has a low combustible loading and the separation is sufficient to avoid damage to Bldg. 1006A.

The STAR Complex is located in the middle of the Pine Barrens. Pine trees and shrubs do pose a potential exposure to the insulated metal structures. Although the frequency of occurrences are very low, wildland fires are a possibility. While the roof systems will not ignite from burning brands produced in a brush fire, the metal walls will not provide a significant fire barrier. Distance is the key element for protection. A minimum 50 ft. distance (100 ft. for upward slopes) is required to protect the structure. The conditions are acceptable now. Efforts will be needed to maintain theses

8. Environmental Impact due to a Fire (Including Water Runoff)

Toxic, biological, and radiation incidents resulting from a fire, including water runoff, are analyzed in sections 8.1 through 8.3, below.

8.1 Toxic Incident

There are no known materials in the STAR Detector that, if involved in a fire, would result in a significant quantity of toxic material being created and released.

8.2 Biological Incident

Due to the lack of biological matter at this facility, an incident of this type is unforeseeable.

8.3 Radiation Incident

By the nature of the operations of the accelerator, various pieces of equipment can be expected to become activated. This activation is not expected to pose a significant environmental impact in the event of a fire since the material will not be easily disbursed.

For calibration of instruments, several small sealed calibration sources will be present. These sources do not have the curie content nor the physical state to be disbursed and contaminate large areas.

No other radioactive materials are used or stored in the STAR Complex.

9. Prefire and Emergency Planning

The BNL Fire Department maintains an adequate prefire plan book for this facility. "Hold Points" are defined so that the Fire/Rescue Group will wait until conditions are safe prior to approaching the facility.

A Local Emergency Plan is maintained by the Facility. It includes Control Room actions to take with various alarms.

9.1 Fire Apparatus Accessibility

Fire apparatus accessibility is adequate for the main facility. Current parking lot configurations allow access by apparatus in the event of an emergency.

10. Life Safety Considerations

Major life safety considerations for this industrial facility include the following components; means of egress components and capacity, number and arrangement of the means of egress, travel distances to exits, discharge from the exits, and emergency lighting and marking of the means of egress.

The likelihood of a fast spreading fire is remote, given the nature of P-10. No other substance poses a high fire hazard. Hence the facility is an "ordinary hazard special purpose industrial occupancy" by the Life Safety Code. The anticipated occupancy load is less than 25 people for the WAH. The WAH has three means of egress. Two exits are available through the two labyrinths.

A third exit is available through the east tunnel. The tunnel exit is required due to the Life Safety Code requirement for remoteness of exits. The tunnel exit has a radiation security gate that is crashable into the tunnel. The gate can be opened by pushing a hand through a clear panel and turning a knob. Personnel in the area are trained in the use of these standard gates and can easily operate them. While this arrangement is not clearly defined in the Life Safety Code, it meets the intent of an easily operated mechanism. The exit widths are sufficient to accommodate the occupant load.

The AH has two means of egress, one from the east side and one from the north west. Occupancy of this area is more routine and more populated. Maximum occupancy is not expected to exceed 100. Exit widths are sufficient to accommodate the occupant load.

The Mezzanine in the AH is a restricted area. A maximum of five people is expected at any one time. Only authorized personnel are permitted. This area has two exits due to the common path of travel requirement. The east exit discharges onto a platform. From the platform, a ladder brings the people to grade. The Life Safety Code allows ladders for use by three or less people. The ladder conforms to ANSI requirement.

Lighting for all areas is on the Bldg. 1006A's emergency generator.